

A population-based observational morphologic measurements of anatomic landmarks in maxillary and mandibular molar

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ABSTRACT

Aim: The aim of this study is to study the morphological measurements of external and internal anatomic landmarks in human maxillary and mandibular molars and their correlation with critical pulp chamber morphology.

Materials and Methods: A total of 200 mandibular and maxillary molar teeth of patients were evaluated. Teeth whose pulp chamber were not violated by caries, restoration, fracture crown, and those having closed apex were included in the study. Teeth were subjected to radiovisiography of bitewing projection and imaging tool was utilized for measuring-A: Distance from the pulp chamber floor to the furcation, B: Distance from the pulp chamber ceiling to the furcation, C: Distance from the buccal cusp tip to the furcation, D: Distance from the buccal cusp to the floor of the pulp chamber, E: Distance from the buccal cusp to the ceiling of pulp chamber, and F: Pulp chamber height. Differences in the measurements were examined using the Student's *t*-test and Pearson correlations. All results were considered statistically significant if $P < 0.05$.

Results: There were significant differences found among the various measurements between young and old population groups ($P < 0.05$). The highest percentage variance was found for the height of the pulp chamber ($P < 0.001$).

Conclusions: The knowledge of pulp chamber morphology should be integrated with preoperative radiograph and intraoperative tactile perception during endodontic access preparation.

Keywords: Access cavity, anatomic landmarks, bitewing, molar, pulp chamber

INTRODUCTION

Among the various steps of the root canal treatment, a good access is the first and arguably one of the most important phases as it reduces the chances of endodontic failure. However, it can be the most challenging and imperative for a quality endodontic treatment, prevention of iatrogenic problems such as furcal perforations which are often most frustrating aspect of endodontic treatment too.^[1,2]

Access preparations usually demand a qualitative approach through clinician's tactile perception and thorough knowledge of dental anatomy. Although the invent of

high-speed hand piece holds the drawback of loss of control and tactile perception, the laws of access cavity preparation in our standard endodontic textbooks emphasizes on the drop or dip effect while entering the pulp chamber, but this might get adversely influenced by the calcific complications of the pulp chamber, insufficient clinical experience, or poor visibility.^[3] Thus, a blind reliance on tactile perception alone, may yield undesirable results, causing perforation and/or the gauging of the pulp chamber. Perforation through the pulp chamber floor into the furcation of any tooth is a serious endodontic issue and may slow down the prognosis of the tooth, requiring extraction in some cases.^[4]

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Shaw and Jones studied the morphological variations of the pulp chamber from the radiographs and concluded that the pulp chambers dimensions in maxillary and mandibular molars decrease with age due to continuous secondary dentin formation throughout life and apposition of sclerotic and tertiary dentin on the internal walls.^[5] In addition, the crown length also decreases due to the physiological and pathological tooth wear with age.^[6]

Numerous studies have presented with anatomic variations of the root canals among different races of people.^[5-9] However, morphological variations concerning pulp chambers across different races of people are not clearly known and the literature lacks evidence based on ethnic and racial grounds. There are a few radiographic studies conducted on the South Indian population to study the pulp chamber dimensions in molars and have laid stress on the importance of preoperative radiographic assessment to achieve an ideal and conservative access cavity preparation.^[10,11] However, in the North Indian population, there are no such studies conducted.

Therefore, this study aimed to measure the key internal and external anatomical landmarks relating to pulp chamber morphology in maxillary and mandibular molars and validate the precision of such measurements. The hypothesis of the present study was that external and internal anatomic landmarks are not random and that the measurements will be similar in all molar teeth.

MATERIALS AND METHODS

This present observational study was conducted in the department of conservative dentistry and endodontics. This study was based on the Western U. P population. Subject after getting approval from the Institutional Ethical Committee vide letter Reference No. SDC/E. C/2018/dated on 20.03.2018, written informed consent was obtained from all the participants to access their digital radiographs – the consent form requesting details of their age, sex, and the ethnicity of their parents and their grandparents. A total sample size of 200 patients was selected as per previous study conducted by Deutsch and Musikant.^[12]

Noncarious, mature molars without a history of root canal treatment or restoration, patients in the age group between 21 and 60 years, and natives of Western U. P. were included in this study. They were placed into two groups based on chronological age as Group 1: 21–40 years and Group 2: 40–60 years. There were 100 patients each in Group A and B. 100 patients of each group comprised of 50 males and 50 female patients, of which 50 maxillary and 50 mandibular

radiographs were studied. Equal number of patients, comprising of 50 males and 50 females were taken from the outpatient department so as to study if sexual dimorphism could result in anatomic variation in landmarks. Further maxillary and mandibular molars both were taken in the study.

Maxillary and mandibular molars of patients of different age groups (young and old) were subjected to radiovisiography (RVG), using the model Kodak Carestream RVG 5200 digital radiography system. RVG of bitewing projection, supporting the sensor in a Rinn XCP bitewing holder and beam alignment device (paralleling device) designed by the company, Dentsply Sirona. The XCP device has a collimator ring that is parallel with the film-holding plane of the X-ray film holder. This positioning helps to align the plane of the unseen, intraorally located X-ray film parallel with the plane of the cross section of the X-ray beam.

All the radiographs were shot by an experience radiographer in bitewing projection and were exposed for 0.18 s at 70 kVp and 8 mA.

The digital recorded images were studied, and image calibration of different morphological anatomical landmarks was made by the measuring tool in the software, KODAK RVG 5100 Digital dental imaging software [Carestream Health Inc, Atlanta, U.S]. Six anatomical landmarks measurements were made by two operators separately (who were blinded about patient information) with the help of the imaging tool to eliminate the observer bias and in case of disagreement consensus were made after discussion and recorded [Figures 1 and 2]. For each landmark, reading was made thrice, and the mean was taken as final data. In Figure 1, anatomic landmarks are denoted by various color codings:

A: Yellow, B: Blue, C: Black, D: Red, E: Green, and F: Purple

Measurement-A: Distance from the pulp chamber floor to the furcation. Measurement-B: Distance from the pulp chamber ceiling to the furcation. Measurement-C: Distance from the

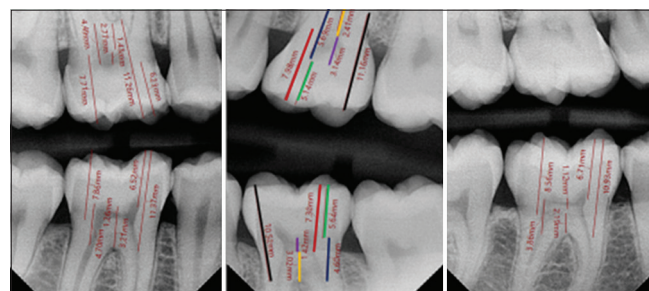


Figure 1: Bitewing radiograph of maxillary and mandibular molars showing measurements of various landmarks in the young population. A: Yellow, B: Blue, C: Black, D: Red, E: Green and F: Purple

buccal cusp tip to the furcation. Measurement-D: Distance from the buccal cusp to the floor of the pulp chamber. Measurement-E: Distance from the buccal cusp to the ceiling of pulp chamber. Measurement-F: Pulp chamber height. In statistical analysis, all the calibrations were recorded, and the mean morphological measurements were made.

Detailed percentage variance was calculated for all the measurements. Differences in the measurements were examined using the Student's *t*-test and Pearson correlations.^[13] All results were considered statistically significant if $P < 0.05$. Statistical Package for the Social Sciences (20.0) software package (IBM, Chicago, IL, USA) was used to study the various analysis.

RESULTS

The mean, standard deviation, and coefficient of variation

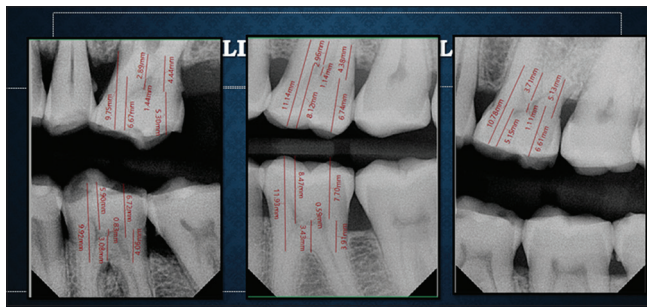


Figure 2: Bitewing radiograph of maxillary and mandibular molars showing measurements of various landmarks in the old population.

for each measurement are presented in Table 1. Statistically significant differences were found in the mean sizes of pulp chamber between the young and old population ($P < 0.001$). The mean measurements of different anatomic landmarks were collectively calculated for maxillary and mandibular molars, and comparison was made between the two groups. Significant differences were noted for certain measurements [Table 2].

DISCUSSION

Based on the evidence in the literature regarding significant craniofacial differences among North Indian versus South Indian population, it can be presumed that the same morphological and anatomic differences might exist in dental tissues as well.

Hence, this *in vivo* study was conducted in North Western Uttar Pradesh population with an aim to measure external anatomical landmarks and their correlation with critical morphology of pulp chamber in mandibular and maxillary molars using intraoral bitewing radiographs and to check for anatomic differences, if existed any. As the pulp space morphology is dynamic in nature and changes with age and the dimensions of tooth also changes with age thus two different age groups patients were evaluated in this study to find out influence of age on different landmarks. None of the studies in the literature have been conducted on both maxillary and mandibular molars simultaneously, neither have included all the parameters, like one done in the present study.

Table 1: Comparative evaluation of measurements of different anatomic landmarks in mm by their mean, standard deviation, percentage variance, and *P* value between young and old population

Measurement	Young		Old		<i>t</i>	<i>P</i>
	Mean±SD	Percentage variance	Mean±SD	Percentage variance		
A	2.713±0.514	18.946	3.171±0.743	23.431	5.079	<0.001**
B	4.996±0.870	17.414	4.711±0.899	19.083	2.281	0.024*
C	11.609±1.003	8.640	10.377±0.953	9.184	8.910	<0.001**
D	8.608±1.078	12.523	7.062±0.892	12.631	11.053	<0.001**
E	6.463±0.759	11.744	5.604±0.851	15.186	7.530	<0.001**
F	2.193±0.946	43.137	1.378±0.797	57.837	6.593	<0.001**

Student *t*-test unpaired: * $P < 0.05$, significant; ** $P < 0.001$, highly significant. SD: Standard deviation

Table 2: Mean measurements of different anatomic landmarks of maxillary and mandibular molars recorded collectively

Measurement	Maxillary		Mandibular		<i>t</i>	<i>P</i>
	Mean±SD	Percentage variance	Mean±SD	Percentage variance		
A	2.884±0.651	22.573	2.995±0.699	23.339	1.162	0.247
B	5.142±0.874	16.997	4.592±0.832	18.118	4.559	<0.001**
C	11.256±1.196	10.625	10.756±1.067	9.920	3.122	0.002*
D	8.102±1.379	17.020	7.594±1.081	14.235	2.910	0.004*
E	6.005±0.934	15.554	6.059±0.895	14.771	0.425	0.672
F	2.171±0.899	41.409	1.437±0.887	61.726	5.802	<0.001**

Student *t*-test unpaired: * $P < 0.05$, significant; ** $P < 0.001$, highly significant. SD: Standard deviation

A paralleling device with standardized voltage, current and time was used to shoot each bitewing radiograph. Along with this magnification tool and invert image tools were also utilized to understand the digital image better before marking and making measurements of various landmarks for minimizing the errors.

On comparison of mean values of younger group in the present study with older group, significant differences can be noted in the mean values of the distance from the pulp chamber floor to furcation and in the height of the pulp chamber which has directly influenced the mean distances of all other landmarks in the older population. Layering of secondary dentin more toward the roof and pulp chamber floor as compared to other sites as the age advances is the reason of increase dimension of landmark A. Landmarks B, C, D, E, and F remain affected due to the same aforementioned reason.

The mean dentin thickness between the pulp chamber floor and furcation (A) for maxillary molars was observed to be 2.88 mm. Deutsch and Musikant^[12] when observed the same landmark in their population found it to be 3.05 mm and Khojastepour *et al.*^[14] found it to be 3.18 mm. Another study by Velmurugan *et al.*^[10] found it to be 2.7 mm which was in accordance with the result of the present study.

The difference observed between the Indian and foreign studies result may be due to the difference in ethnic diversities. This observation again reinforces the thought that the values for different parameters should be checked from population to population rather than following blindly on any of the conducted studies in the world.

The mean dentin thickness from the pulp chamber floor till the furcation (A) for mandibular molars was observed to be 2.99 mm. The mean measurement from the buccal cusp tip till the furcation in maxillary molars was observed to be 11.27 mm which is in accordance to the study conducted by Velmurugan *et al.*^[10] When the same landmark, i.e., C was observed in mandibular teeth, the mean value came to be 10.75 mm which is again agrees with the study conducted by Deutsch *et al.*^[15] and Khojastepour *et al.*^[14]

The mean measurement from the buccal cusp tip to the pulp chamber floor (D) was observed to be 8.10 mm for the maxillary molars. On observation of Landmark D in mandibular molars, the mean value came to be 7.59 mm, which is quite near to the same landmark observation done by Deutsch *et al.* The height of tooth structure from the buccal cusp tip to the pulp chamber ceiling came out as a mean value

of 6.0 mm which was slightly lower than the studies done by Khojastepour *et al.* and Velmurugan *et al.* [Table 2]. The pulp chamber size in mandibular molars was smaller than the pulp chamber size of maxillary molars which is in accordance with a study by Deutsch, Khojastepour, and Lokade *et al.*^[16]

As the pulp chamber size as well as the dentin thickness from the pulp chamber floor to the furcation was seen to be more in maxillary molars than their counter mandibular molar. Thus, the landmark B was also found to be more than mandibular molars in the present study. When the thickness of dentin in the furcation area was compared among mandibular and maxillary molars, it was more pronounced in mandibular molars.

However, statistically significant difference was not found. The slight increase of this value in mandibular molars can be explained by higher masticatory load beard by mandibular molars when compared with maxillary molars. Numerous studies suggest that secondary dentin apposition occurs primarily on the floor of the pulp chamber instead of the ceiling.^[5,17,18]

Tidmarsh stated that “the growth of dentin upon the pulp chamber floors, apparently without cause, is of some significance to the endodontist who desires to gain entrance to the root canals.”^[18] However, the result of this comparison is contradictory to what it is observed by Deutsch and Musikant. The mean value of the distance from the buccal cusp tip to the furcation (C) in maxillary molar was found to be 11.256 mm which was slightly more than the mandibular molars (10.75 mm) for the same landmark.

Similarly, the distance from the buccal cusp tip to the pulp chamber floor observed in mandibular molars was found to be significantly less than maxillary molars that is, 8.102 mm which can be attributed to the fact that mandibular molars have smaller pulp chamber size, have greater deposition of secondary dentin at the floor of pulp chamber and more wear.^[19] Percentage variance was recorded largest for the landmark F which represents the pulp chamber height.

This inter-tooth variation in the height of the pulp chamber is probably the result of secondary dentin apposition. This is in accordance to the study conducted by Azim *et al.*^[20] The thickness of the pulp chamber decreases with age indicating the deposition of dentin.^[13,19] The dimensions of pulp chamber should be related with the age.

This is important during access cavity preparation as the drop effect cannot be appreciated. With the use of ultrasonics and

magnification, we do not need to necessarily rely on the drop effect but a very few clinicians are operating under magnification. A study conducted on comparative evaluation of endodontic practice trends in India revealed that only 4.6% of the respondents used magnification >75% of the time.^[21] The results of another study assessing the awareness and attitude of dental surgeons toward magnification showed that 78.1% did not use any magnification during dental procedure,^[22] thus necessitating the knowledge of anatomic variations in external landmarks while making an access. The second largest variation was observed for landmark A, which is again influenced by the apposition of secondary dentin. An interesting finding to be noted in the present study is that the measurements from the cusp tip to furcation and various points in the pulp chamber were the least variable of all the measurements that is landmark C, D, and E. The results of this study agree with the results of Deutsch and Musikant.

Affixing a stop or a mark on a bur 6–6.5 mm from the cutting tip will enable the dentist to drill into the middle of the pulp chamber without fear of iatrogenic perforation. In cases, where operator yet fails to negotiate the canals, it is advocated to take a radiograph to look for calcific complications in the pulp chamber.

All the measurements were made digitally using the magnification and invert image tool and measuring each landmark thrice to get final reading by two operators to minimize errors and bias. In the present study, there was focus only on tooth without restoration or decay violating the pulp chamber to allow adequate identification of the studied parameter.

The limitation of this study was that the bitewing radiographs provided only two dimensional information. A cone-beam computed tomography would have given information in all three dimensions.

It is noteworthy that teeth with restoration or decay encroaching on to the pulp chamber are the most problematic during access preparation. However, the low CV of measurements of D and E and the consistency of results with other reports indicate that these readings can be used as guidelines for accessing those altered teeth as well.

CONCLUSION

Prior to access cavity preparation pre-evaluation of bitewing and IOPA radiographs is a must requirement in absence of CBCT for successful endodontic access. In addition to

age, wear, injury and secondary dentin formation, ethnic variation do influence the internal and external landmarks. Thus population with ethnic community should be evaluated individually for making the guidelines.

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Conflicts of interest

There are no conflicts of interest.

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